

Thermal Habitat Use and Evidence of Seasonal Migration by Rocky Mountain Tailed Frogs, *Ascaphus montanus*, in Montana

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All life stages of Rocky Mountain Tailed Frogs (*Ascaphus montanus*) occurred in a reach of Moore Creek, Montana, where water temperatures exceeded those previously reported for *Ascaphus* in the wild. However, relative density of *Ascaphus* in the warmest reach, immediately downstream of a lake outlet, was lower than in cooler reaches downstream. Although we observed larvae and frogs in water temperatures up to 21°C, cold groundwater seeps contributed to a spatially complex thermal structure in the warmest stream reach. Frogs congregating near a cold seep and nesting in a groundwater-influenced site were likely using behavioral thermoregulation. At a stream weir in the warmest reach, we captured 32 Tailed Frogs moving downstream and none upstream, in September and October 1997. Because no migration was evident at five other weirs where summer water temperatures remained below 16°C, we propose that the frogs moving through upper Moore Creek migrated seasonally to avoid the high temperatures. The mature frogs may spend summers in the small, cold lake inlet streams, moving downstream in the fall to overwinter. Behavioral studies would be necessary to determine the extent to which individuals limit their overall thermal exposure in such spatially complex environments. Migration in response to local, seasonally changing habitat suitability could explain the diverse, and apparently contradictory, movement patterns (or lack thereof) among *Ascaphus* populations reported in the literature. Future studies of *Ascaphus* movements could benefit by accounting for seasonal changes in habitat suitability and by quantifying in-stream movements.

Key Words: *Ascaphus montaniis*, Tailed Frog, amphibian, water temperature, thermal complexity, habitat, movements, migration, behavior.

Tailed Frogs (*Ascaphus truei* and *A. numtams*¹) live in cold, rocky streams in the Pacific Northwest and northern Rocky Mountains (Nussbaum et al. 1983) of the USA and in southwestern Canada. Although important to understanding the species' habitat use, population dynamics, gene flow, and recolonization abilities, *Ascaphus* movements are not well documented. Mark-recapture studies directed at detecting movements of transformed *Ascaphus* have concluded that site fidelity is high among mature individuals (Daugherty and Sheldon 1982a) or have been inconclusive (Metier 1964a). Three reports suggested that transformed frogs migrated seasonally; however, direct evidence of movement was lacking (Metier 1964a; Landreth and Ferguson 1967; Brown 1975). Such inconsistencies could reflect either shortcomings in the studies or spatial and temporal variations in movement patterns.

Thermal tolerances and tolerance ranges of *Ascaphus* are lower than for any other anuran studied

in North America (reviewed by Claussen 1973). Reports of *Ascaphus* occurrence are generally from streams with maximal temperatures not exceeding 16°C (Franz and Lee 1970; Welsh 1990). Laboratory experiments suggest that thermal tolerances vary among the life history stages. Critical examinations of whether temperature actually limits *Ascaphus* distributions are lacking.

In Rocky Mountain *Ascaphus* populations, individuals transform at age 4, first mature at age 8 and can live for 14 or more years (Daugherty and Sheldon 1982b). The frogs typically mate in the fall (but see Went 1969), and females retain sperm until the following July when they lay eggs (Metier 1964b). Eggs usually hatch in late summer, but larvae apparently remain in the nest site until the following summer (Metier 1964a; Brown 1975). This implies that eggs and larvae experience the thermal regime at the nest site throughout an entire year.

Incidental to a study of introduced Brook Trout (*Salvelinus fontinalis*) in two Montana streams (Adams 1999), we made new observations on *Ascaphus* seasonal movements and occurrence in warm water temperatures. We subsequently assessed *Ascaphus* relative abundances and water temperatures throughout one stream-lake network to determine how water temperature was related to summer distributions of each life stage and to timing of downstream frog movements.

¹Nielson et al. (2001) recommended that inland populations of Tailed Frogs be recognized as a distinct species (*Ascaphus inonianus*). Minor inconsistencies between our text and the existence of two distinct *Ascaphus* species occur because our paper was already in press when we read Nielson et al. (2001).

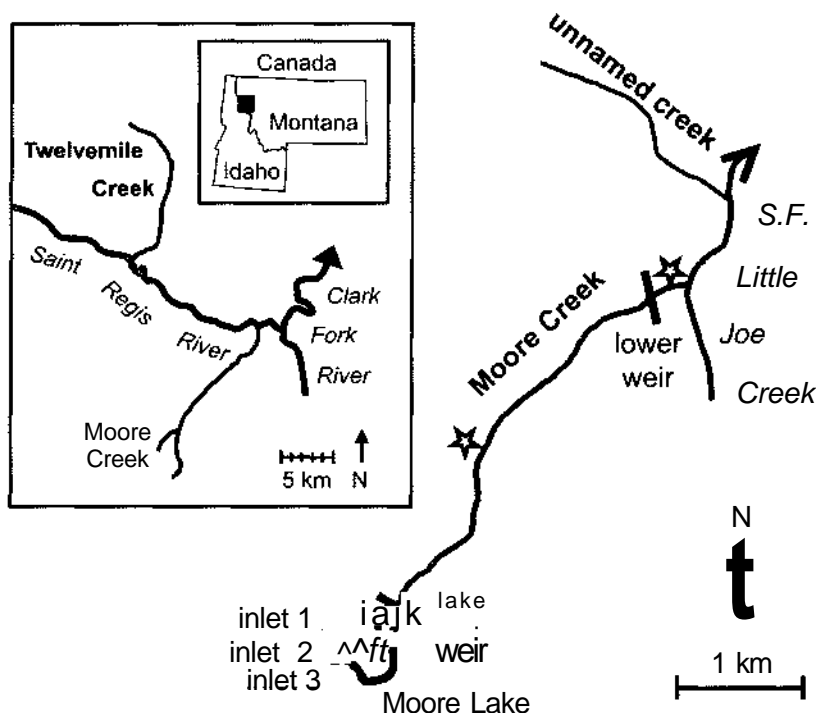


FIGURE 1. Locations of Moore and Twelvemile creeks in Mineral County, Montana, USA, and detail of Moore Creek showing locations of weirs (bars) and temperature recorders (stars). The lake weir was about 75 m downstream of the lake outlet and 5 m downstream of the upper temperature recorder. The lower weir was 120 m upstream of the confluence with South Fork Little Joe Creek.

Materials and Methods

Moore Creek (St. Regis River drainage, Mineral County, Montana, 47°11'N, 115°15'W) is 3.2 km long and is fed by Moore Lake, a 16-m deep, 5.3 hectare, headwater lake at 1620 m elevation. About 320 m of shoreline separates the closest of three, small, lake-inlet streams from the outlet stream (Figure 1). During late summer low flows, average wetted stream widths ranged from 1.8 m near the lake outlet to 3.2 m near the mouth, channel slopes ranged from 10 to 19%, and average maximum pool depth near the lake outlet was 0.23 m. Riparian vegetation was predominantly Western Redcedar (*Thuja plicata*) forest. Twelvemile Creek is larger, longer (22.6 km), and more moderately sloped than Moore Creek with wetted widths ranging from 1.8 to 9.6 m in summer and channel slopes from 1.3 to 8.1 %.

We intermittently counted Tailed Frogs trapped at two weirs in Moore Creek (Figure 1) from 6 August to 9 October 1997 (dates shown in Figure 2) and at four weirs in Twelvemile Creek from July through late September 1997. We checked traps every 2 to 3 days during operation, and the longest period without counting frogs was 12 to 28 September, 1997. The weirs, constructed of 6.35 mm hardware cloth,

consisted of two traps facing in opposite directions and connected to each other and to shore by a fence (see Figure 1b in Gowan and Fausch 1996). An apron buried in the substrate prevented animals from easily passing under the weir. Each trap box was a 60 X 60 X 60 cm cube with a funnel extending almost to the back. Large rocks in the traps provided shelter and velocity refugia for captured animals, and lids minimized predation. After identification, animals were released beyond the weir in the direction they were moving when trapped.

We located *Ascaphus* via snorkeling and electrofishing targeting Brook Trout in Moore and Twelvemile creeks in 1997 and via visual surveys targeting *Ascaphus* in Moore Creek in 1998. In July 1998, students assisted with day and night searches for *Ascaphus* along sections of the lake inlet streams, the lakeshore between Moore Creek and the inlet, Moore Creek, and an unnamed creek near Moore Creek (Figure 1). We performed timed searches, turning over streambed rocks and visually scanning both the streambed and stream banks within 2 meters of the stream. The results are intended only for describing *Ascaphus* distribution and for a qualitative comparison of relative densities among reaches.

The lakeshore, one inlet stream, and the uppermost Moore Creek reach were again searched during the night (and Moore Creek also during day) of 7-8 October 1998.

Hobo-Temp® data loggers recorded stream temperatures from 31 July 1997 to 8 October 1998 (with several gaps) at three locations each in Moore (Figure 1) and Twelvemile creeks. Using a digital thermometer, we took a longitudinal temperature profile in Moore Creek downstream of the lake outlet on 28 July 1998 and took focal point temperatures at some *Ascaphus* locations.

Results and Discussion

Adult movements

At the lake weir in Moore Creek, we trapped 32 frogs moving downstream and one moving upstream. As the trapping period progressed, the number of adult *Ascaphus* moving downstream into the trap increased from no frogs for the period of 7 August through 3 September 1997 to nine frogs on 6 October, three days before the weir was removed (Figure 2). The sex ratio of captured frogs was male biased (chi square = 6.1250, $p = 0.0133$).

The timing of frog captures coincided with a drop in water temperature (Figure 2). The frogs began moving downstream into the trap when average daily stream temperatures dropped below 16°C, and most

were captured when average temperatures fell below 14°C (Figure 2). Whenever frogs were recorded in the trap, the maximum daily temperature had not exceeded 16.5°C during at least one day of the two-to-three-day trapping interval.

The pattern of frog captures suggests that a directed, seasonal migration was occurring in upper Moore Creek. The seasonality of the movement is clear from the complete absence of any frogs in the downstream trap for at least the first month of operation. Although there was unquestionable directionality of capture in the traps, concluding that a downstream migration was actually occurring depends on two assumptions: (1) that the weir was not biased against capture or retention of frogs moving upstream, and (2) that the frogs were not moving upstream over land.

We caught no frogs at the lower weir in Moore Creek or at any of the weirs in Twelvemile Creek, although the frogs and larvae were present throughout both creeks (Figure 3) (Franz 1970; S. Adams, personal observation). Thus, *Ascaphus* movement patterns can vary not only among, but also within, streams. The limited literature on *Ascaphus* movements also indicates that movement patterns may vary considerably among drainages. Daugherty and Sheldon (1982a) found no evidence of seasonal or directed movements by mature Tailed Frogs in

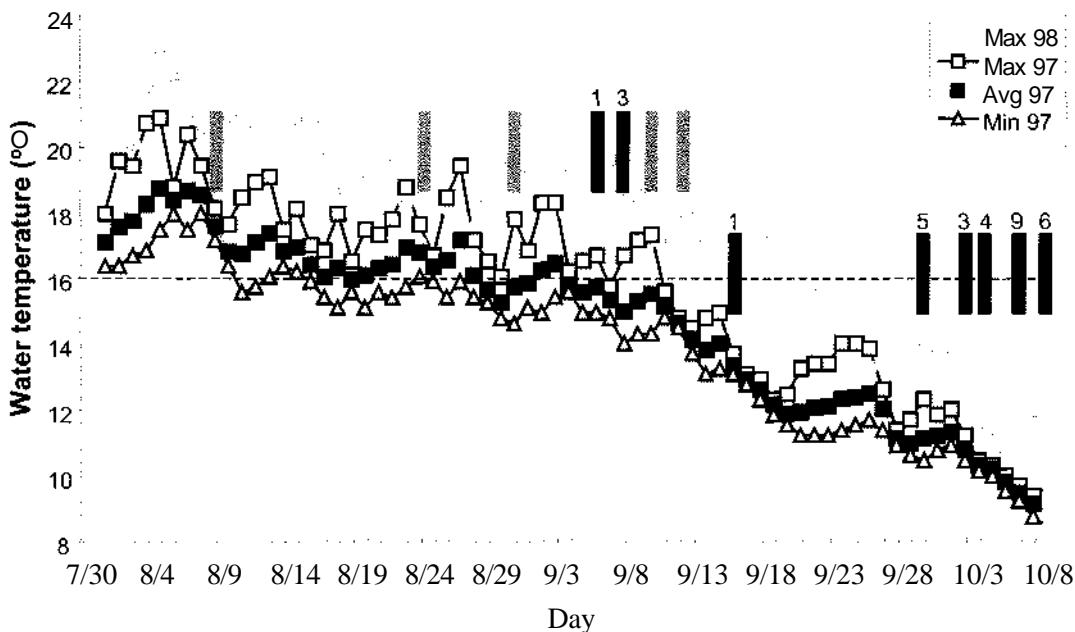


FIGURE 2. Average (avg), maximum (max), and minimum (min) daily stream temperatures 5 m upstream of the "lake weir" in Moore Creek, Montana, 1997 and 1998. Vertical bars indicate dates in 1997 when frogs were counted in traps at the "lake weir". Grey bars represent the absence and black bars the presence of frogs moving downstream. Each bar represents 2 to 3 days of trapping. Numbers of frogs counted are indicated above bars.

able habitat features may help explain the diversity of movement patterns reported in the literature. Future studies of *Ascaphus* movements could benefit by accounting for seasonal changes in habitat suitability and by quantifying in-stream movements rather than focusing primarily on terrestrial movements.

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